



COASTAL HERITAGE

VOLUME 24, NUMBER 4

SPRING 2010

The Dynamic Coast
Living with Shoreline Change

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The Stono River snakes through lowcountry salt marshes to the Atlantic Ocean.

PHOTO/WADE SPEES



*Celebrating 30 Years of
Science Serving South Carolina's Coast*

Coastal Heritage is a quarterly publication of the S.C. Sea Grant Consortium, a university-based network supporting research, education, and outreach to conserve coastal resources and enhance economic opportunity for the people of South Carolina. Comments regarding this or future issues of *Coastal Heritage* are welcomed at John.Tibbetts@scseagrant.org. Subscriptions are free upon request by contacting:

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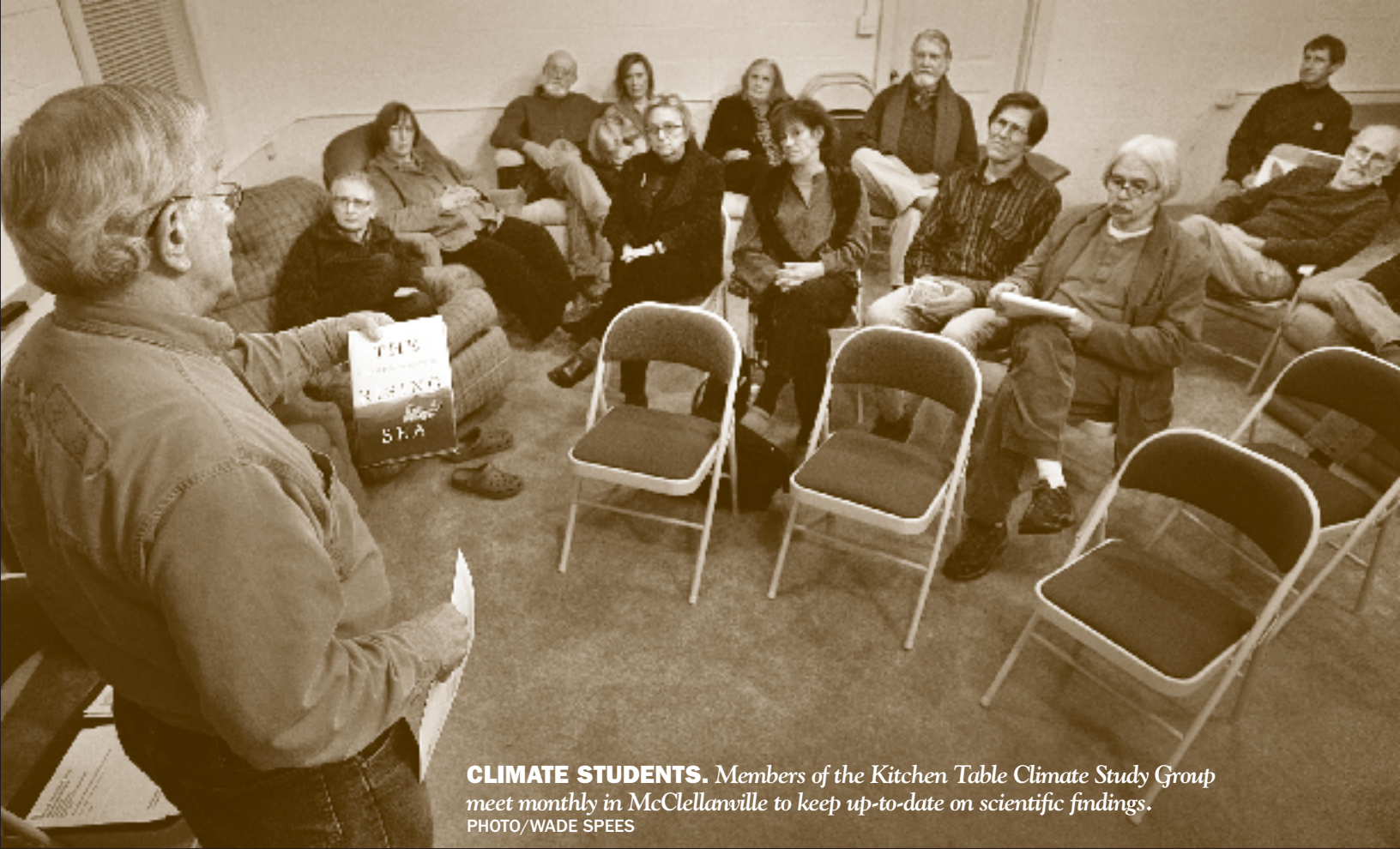
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CLIMATE STUDENTS. Members of the Kitchen Table Climate Study Group meet monthly in McClellanville to keep up-to-date on scientific findings. PHOTO/WADE SPEES

The Dynamic Coast

Living with Shoreline Change

by John H. Tibbetts

Daniel Fifis and his wife Carol McClellan have watched tides rise higher and higher over the past 25 years at their marshfront home on Jeremy Creek in McClellanville (pop. 500). They live across the creek from a commercial fishing dock and just upstream from vast salt marshes, five-miles wide, which buffer the fishing village from the worst of Atlantic storm waves.

In 1985, the couple built their elevated home on a rise on the landward side of their three-acre lot. The house has stayed dry during hurricanes, even during Hugo's 17-foot storm surge in 1989, but their yard has shrunk dramatically because of rising water.

When hurricanes barrel north along the coast, storm surges roll over the giant marshes, tear into the

shoreline, and damage neighbors' docks.

"We're good observers," says Fifis. "We used to have a brief flood twice a year. Now water can come into our yard twice a month and stay for a week at a time, covering about a quarter acre."

Fifis, a retired psychologist, estimates that his marshfront shoreline has migrated inland about 50 feet since the mid-1980s. Neighbors have similar problems, which probably have been caused by a number of factors, including natural land subsidence, waterway dredging, storm surges, and sea-level rise.

"This is our little piece of heaven," says Fifis, "but we know that global sea level will rise faster in the future because of climate change. Someday

this house will be on the water. In our case, we'll just adapt."

Fifis and McClellan are members of the Kitchen Table Climate Study Group, a volunteer organization of a few dozen citizen-activists from McClellanville and surrounding rural areas. They gather monthly to keep up-to-date on scientific findings on climate change. Today, scientists are calling for steep reductions in greenhouse-gas emissions while also emphasizing adaptation—that is, finding ways to live with climate change.

Most Kitchen Table members are older and aren't worried about major disruptions to the coast in their lifetimes. "Our group," Fifis says, "is really concerned about our children." He and his wife have two daughters, ages 29 and 26, who spent weekends,

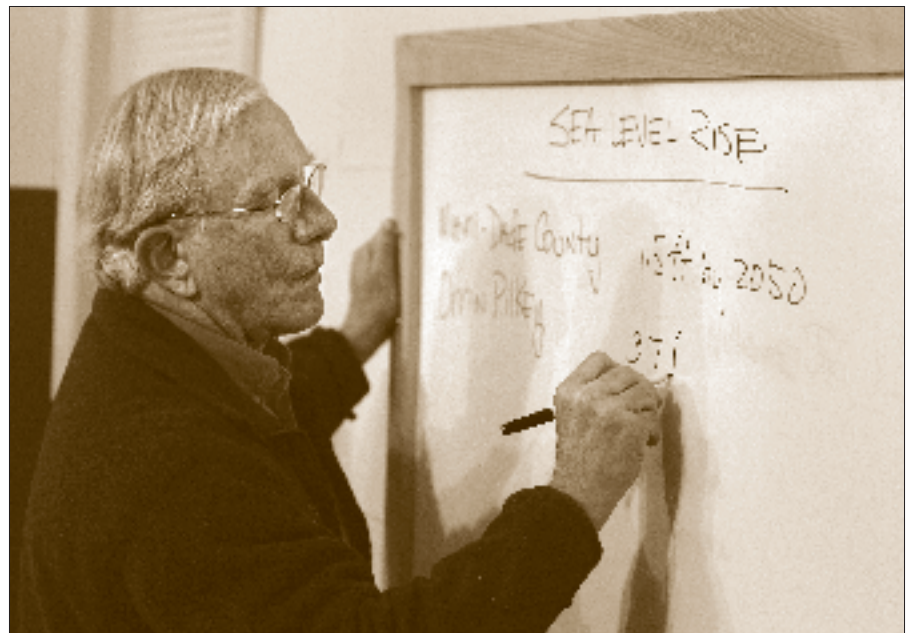
holidays, and summers on Jeremy Creek as kids. “Our goal is to pass the property on to them,” he says.

Over the span of the twentieth century, average global sea level rose by 1.8 millimeters (0.07 inch) a year. That’s the thickness of one U.S. quarter coin per year. Which doesn’t sound like much, but it’s contributed to coastal erosion in many low-elevation locations around the world.

Since 1990, global sea level has accelerated its pace, reaching 3.2 millimeters (0.126 inch) annually, or nearly the thickness of two quarters.

Global sea level will likely rise about one meter (almost three feet) and perhaps even to two meters (almost seven feet) by 2100 primarily because of continuing changes in polar ice sheets. That would have a dramatic impact on many U.S. coastal communities. For example, a 0.7 meter (27 inches) rise would inundate 70% of Miami-Dade County, which houses one-tenth of Florida’s current population.

Governments should assume that global sea level will rise seven feet by 2100, according to Rob Young, director of the Program for the Study of Developed Shorelines at Western Carolina University, and Orrin Pilkey,



TUNED-IN. David Stoney, director of the Kitchen Table Climate Study Group, highlights recent forecasts of global sea-level rise and potential impacts on coastal communities.

PHOTO/WADE SPEES

a professor emeritus of geology at Duke University, in their 2009 book *The Rising Sea*. Seven feet, they argue, should be the conservative planning guideline for coastal communities, especially when planning and building major infrastructure.

Still, “sea level rise doesn’t stop at

2100,” says Stefan Rahmstorf of the Potsdam Institute of Climate Impact Research in Germany. “We’re looking at several meters of sea level rise over centuries unless we slow emissions quickly.”

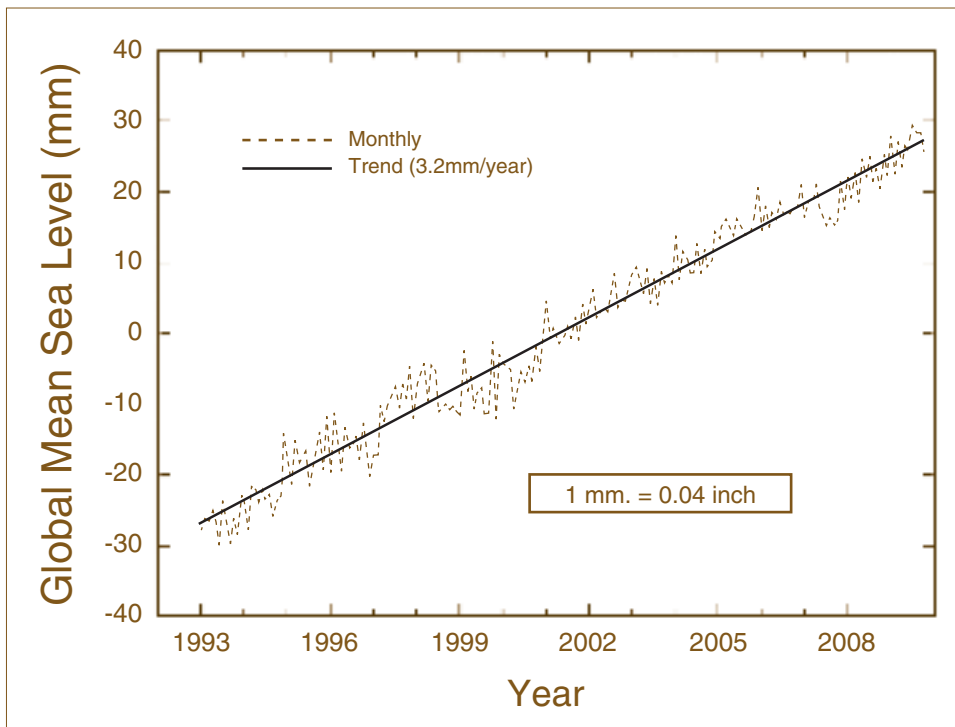
So how can we adapt to rising water? What’s our menu of options?

One strategy is to retreat and give up some land to the sea. Some states and localities are restricting or prohibiting new construction in flood-prone places through easements, setbacks, acquisition of lands, and other tools. Some states, including South Carolina, prohibit construction of new oceanfront seawalls or their reconstruction after storms.

But retreat is a hard sell in many places. “Politically, it’s not popular to talk about retreat yet,” says Josh Foster, manager of climate adaptation for the Center for Clean Air Policy, a nonprofit organization based in Washington. “But it should be part

Satellite measurements of global sea-level rise indicate a rapid increase since the early 1990s.

SOURCE/COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION



of the equation—and soon.”

Sophisticated coastal states and localities aren't depending on one strategy alone. Instead, they are combining retreat policies with an assortment of the following tools:

- adding sand to beaches (beach nourishment) and preserving marshfronts with vegetated buffers;
- raising roads and bridges to cope with more flooding and storm surges;
- elevating or relocating fire stations, hospitals, and other public works and important community assets;
- improving building codes and construction practices to raise coastal buildings and make them stronger and more able to survive floods and high winds;
- building seawalls, bulkheads (wooden seawalls), revetments (sloping concrete seawalls), riprap (large rocks), or “living shorelines” when necessary to protect intensively developed shorelines and valuable infrastructure.

The problem with this last option is that hard structures increase the loss of natural buffers such as beaches and salt marshes and can eventually lead to costly disasters. Hard erosion-control structures can also divert high water to other sections of coastline, increasing flooding there.

“So much depends on your time frame,” says Braxton Davis, director of the policy and planning division at the S.C. Department of Health and Environmental Control–Office of Ocean and Coastal Resource Management (SCDHEC–OCRM). “If you have a short-term view, then you build a levee to protect development, and it can reduce your risk to flooding. But as a result you're more likely to increase development behind the protective levee, and if a storm overwhelms it, then you have increased your vulnerabilities over the long-term.”

That's called the “levee effect”—a shorter-term solution with unintended consequences. People in New Orleans, for instance, faced catastrophic flooding after its levee protections failed



LEVEE EFFECT. *Building a levee to contain coastal flooding is a short-term solution as global sea level continues to go up. After Hurricane Katrina broke levees in New Orleans, flooding swamped entire neighborhoods.*

PHOTO/WADE SPEES

during Hurricane Katrina in 2005.

Since the 1930s, the South Louisiana coast has lost hundreds of square miles of storm-buffering marshes. The U.S. Army Corps of Engineers has dredged waterways and built river levees to improve navigation and protect farmland and urban areas from flooding.

The deeper, faster Mississippi River carried its muddy flows into the Gulf of Mexico, beyond the continental shelf, where sediments were deposited in the deep ocean. The Corps also poured dredge materials from river bottoms off the continental shelf. Crucial wetland-building sediments, then, were lost forever from coastal salt marshes, many of which drowned, turning to open water.

When two giant hurricanes hit South Louisiana in 2005, marsh losses

abruptly increased. Wetlands were broken up and sediments dispersed. The U.S. Geological Survey estimates 217 square miles of coastal lands, including marshes, drowned following hurricanes Katrina and Rita.

“In many locations, we have time to figure out how to adapt to sea-level rise,” says Jessica Whitehead, regional coastal climate specialist with the South Carolina and North Carolina Sea Grant Extension programs. “But major storms can change a coastline rapidly. Shoreline change can occur slowly, over half a century, or it can hit you in a blink of an eye.”

No single event can be attributed to climate change, but Katrina became known to some as a harbinger of troubles in low-lying places. Katrina also changed the minds of some environmentalists who had been



DELUGE. *Walking across the Crosstown Expressway on the morning of Wednesday, Dec. 2, 2009, a woman emptied her boot after heavy rain and a high tide flooded peninsular Charleston.*
PHOTO/ANDY PARAS/THE POST AND COURIER

opposed to focusing on adaptation. They had argued that spending time and money on adaptation would undercut efforts to control greenhouse-gas emissions. “Adaptation has been kind of a dirty word,” says Foster.

Not so any longer. “Climate change is happening, and part of the discussion now is about impacts and methods to deal with impacts,” says Daniel Walker, division chief of climate assessment in the National Oceanic and Atmospheric Administration (NOAA) Climate Program Office. “There will be demand for more and more information to help people make specific decisions.”

The United States will invest \$20 billion to upgrade outdated infrastructure as part of federal stimulus spending. Now, for the first time, some federal agencies and political leaders are considering sea-level rise in their planning.

For instance, the U.S. Army Corps of Engineers will consider sea-level rise as it draws up plans for flood control, navigation, and other water projects under a new agency policy.

“You’ve got a lot of infrastructure at risk,” says Eileen Shea, director of

the NOAA National Climatic Data Center in Asheville, North Carolina. “Policy officials are becoming interested in climate change because we’re at a point where we’re redoing our roads and bridges, changing our airports and railroad infrastructure—and these are 50-year investments.”

Proceed with caution, however.

“Before we undertake an adaptation project such as building a levee, we should think about how it will affect development in hazardous places,” says Andrew Fahlund, senior vice-president of conservation at American Rivers, a nonprofit organization based in Washington, D.C. “Our history shows that every time we try to manipulate waterways to address flooding, there have been unintended consequences.”

So how will coastal residents experience climate change? Sea level rises slowly, but its impacts are felt most strongly during storm flooding. In fact, climate change is already pumping up weather’s muscles, feeding its destructive powers and feverish moods, increasing the ferocity and frequency of storms and floods, according to a June 2009 report by the U.S. Global Change Research Program.

“You have the long-term trend of rising sea level, and then you put storms on top of it,” says Shea. “It’s the combination of sea-level rise and storm surge that will most affect coastal communities.”

A coastline’s chance of facing weather-related disasters, particularly storm flooding, is going up along with the planet’s temperature and sea level. “Extreme rainfall events are translations of global processes to local contexts,” says Shea.

So, there probably will be more floods like the one that struck in Charleston on December 2, 2009. An intense downpour, combined with a high tide, stranded dozens of vehicles in high water and forced police to block road and bridge entrances to downtown Charleston for several hours.

Still, it’s difficult for many coastal residents to grasp the complexities of climate change and sea-level rise, and understand how they or their children will have to adapt.

Now, Jessica Whitehead is collaborating with the Kitchen Table Climate Study Group in McClellanville to provide up-to-date scientific information to local residents.

“You don’t see that kind of citizen effort yet elsewhere on the South Carolina coast,” she says. “The Kitchen Table group wants people to be more informed about climate change, but keeping up with the science is time-consuming. We can help by assembling the latest climate information and presenting it in ways that help the Kitchen Table group stay current and help similar new study groups in the lowcountry get started.”

ADAPTATION: ENGINEER OR RETREAT?

The Dutch are among the world’s most aggressive coastal engineers. One-fourth of the Netherlands, located on river deltas, is beneath sea level and sinking. They have sealed off much of their country’s coastline with dams, dikes, locks, huge storm-surge

barriers, and giant manmade sand dunes; turned brackish estuaries into large freshwater lakes; and continuously pumped water out of the soggy ground.

As a result, they have lost most of their natural shorelines, but they have had little choice. Trapped between the North Sea on one side and the Rhine River system on the other, the Netherlands can't retreat from rising water.

Dutch planners have built 50 prototype "water" houses, some of which float all the time while others only float during floods. The light-weight houses are constructed on platforms composed of concrete and expanded polystyrene, which is commonly used in egg cartons. The Dutch intend to build more of these houses as part of a national adaptation policy.

In New Orleans' Lower Ninth Ward, a newly constructed "Float House," designed by Morphosis Architects for Brad Pitt's Make it Right Foundation, is designed to break away from its moorings during a flood and rise up to 12 feet above ground level on two guideposts. The house would essentially function as a raft. The Morphosis floating house is the first to be permitted in the United States, but its technology was developed and initially used in the Netherlands.

The Netherlands government is also broadening coastal rivers and

canals to absorb storm surges and prevent water from being funneled into urban centers, and it's creating new lands in the North Sea. Near Amsterdam and along the coast, islands are being built for storm protection and some commercial development.

Over centuries, the Dutch have become skilled in adaptive management. They continuously study flood and sea-level threats, revisiting forecasts and rethinking cost-effective tools and approaches.

Tuvalu, a nation of low-lying coral atolls and reef islands in the South Pacific, is taking a starkly different approach from the Netherlands. Tuvalu has lost one-fifth of its 12,000 citizens to emigration, most of them to New Zealand. Many Tuvaluans worry their traditional homes will disappear in a warmer world, and they aren't sticking around to see what happens.

Coastal South Carolinians have an advantage over the Dutch and the Tuvaluans. We are fortunate to have plenty of dry land to retreat to, no matter how high sea level rises. Indeed, South Carolina has an official policy of retreat from 187 miles of coastal shoreline, a region that drives the state's tourism and retirement economy.

In 1988, the South Carolina's legislature enacted the Beachfront Management Act to guide development away from the sea and provide buffers from erosion and storms.

New homes must be set back from the ocean. But more important is the law's seawall provision. Construction of new seawalls is prohibited, and a seawall built before 1988 cannot be rebuilt if 50% of it has been destroyed in a storm.

Seawalls protect oceanfront lots and homes but harm beaches by allowing waves to scour away sand even faster and preventing the

FLOAT PLAN. A new house in the New Orleans' Lower Ninth Ward is designed to float like a raft during floods.

PHOTO/MAKE IT RIGHT FOUNDATION



ENGINEERED. A storm surge barrier in the Netherlands. One-fourth of that country is below sea level, and the Dutch have sealed off much of their nation's coastline.

PHOTO/DREAMSTIME.COM

shoreline from naturally migrating inland as sea level rises. If it can't migrate, the beach disappears under water. The public, then, loses access to the shorefront.

South Carolina's seawall provision is the crux of the state's policy of retreat. South Carolina would not have an effective retreat policy without it.

That's the view of the S.C. Shoreline Change Advisory Committee, comprising 23 experts from academia, government, and the private sector. The committee, convened by SCDHEC-OCRM, has recommended reforms of the state's shoreline management.

Its April 2010 report notes "the state's retreat policy does not provide for the immediate, active relocation of structures from the beach/dune system." But "by gradually eliminating erosion control structures, [the state's retreat policy] ensures abandonment of property to allow the natural, inland migration of a healthy dune system if or when renourishment becomes unsustainable for a specific area or community."





DISAPPEARING ACT. *By 1997, this walkover at Folly Beach County Park had become unnecessary after years of erosion washed away dunes and much of the beach. But a subsequent nourishment project added huge volumes of sand to Folly Beach, widening and raising the shoreline.*

PHOTO/WADE SPEES

In other words, the seawall provision is the only powerful lever in South Carolina's retreat policy. But this provision has never been fully tested in U.S. courts. Would it pass constitutional muster?

The U.S. Supreme Court, legal scholars say, someday might have to decide whether banning seawalls is a taking of private property without compensation or whether such measures are justified to protect public-trust shorelines.

The American "public-trust doctrine" has legal roots in English common law. For centuries, English

courts backed citizens' rights to use waterways and shorelines for fishing and transportation, even when shorelines were privately owned. Waterways, then, were held in public trust largely because rivers and coastal areas were the only reliable highways. The original 13 states adopted the public-trust doctrine upon independence, as did the other 37 states when they entered the union. The U.S. Supreme Court has ruled that states can protect public-trust waterways and shorelines not only for navigation and fishing but also for recreation and other uses.

In South Carolina the public owns coastal property from the ocean to the mean high-tide line—the place along the shoreline where the average high tide reaches twice a day. The state's seawall provision, then, is intended to preserve public-trust areas that would be lost if shorelines were armored and beaches drowned.

BEACH NOURISHMENT AS ADAPTATION STRATEGY

For now, beach nourishment is making seawalls unnecessary along many eroding shorefronts. Over the past two decades, dredging and pumping sand onto beaches from offshore deposits has temporarily raised and restored large stretches of South Carolina's oceanfront.

Twenty years ago, critics argued that nourishment would be too expensive and that most of the sand would wash away in a short time. But many projects have lasted longer than critics expected. And there is abundant evidence that beach nourishment has provided buffers during storm surges and extreme high tides, protecting some properties and coastal infrastructure.

Beach nourishment is "soft" engineering, unlike building "hard" structures such as dikes and seawalls, but it is sophisticated engineering nevertheless.

Indeed, nourishing beaches has become South Carolina's *de facto* management strategy for addressing erosion along many of its sandy shorelines.

But nourishment will probably become increasingly expensive and difficult as communities search for more sources of sediment to pump onto the beaches.

Some parts of the South Carolina coastal ocean are already "sand starved," says S.C. Sea Grant Consortium researcher Paul Gayes, director of the Center for Marine and Wetland Studies at Coastal Carolina University. That is, many regions lack significant offshore sand resources for

future nourishment, and they will need to search elsewhere to mine sand.

“We’re seeing in Louisiana how barrier islands erode rapidly and disappear,” says Abby Sallenger who runs the U.S. Geological Survey storm-impacts research group, which studies how extreme storms change coastal areas. “We can mine sand elsewhere and try to replace what’s lost. But if that happens on a grand scale along the coast as sea level rises, we will have to decide as a society whether we want to spend tremendous levels of resources to do that.”

An unintended consequence of beach nourishment is that new development is often attracted to these dynamic, hazardous places. One problem is that the Beachfront Management Act allows the state’s regulatory zone to be drawn farther seaward after publicly funded nourishment projects have widened shorelines.

This redrawing has allowed some private landowners to build single-family homes or condominiums farther seaward than they could have done before the nourishment projects, even though additional pumping of sand would be required at taxpayers’ expense to keep these beaches wide and stable.

The S.C. Shoreline Change Advisory Committee report recommends

legislative measures that would prevent the state’s regulatory zone from being redrawn seaward under any circumstances.

The committee also recommends permit conditions that would essentially require beachfront landowners to relinquish property rights to any added strips of beach seaward of the high-tide line at the time of nourishment.

But a Florida lawsuit could upend that strategy. Some Florida oceanfront landowners are arguing that publicly funded strips of nourished sand should belong to them as extensions of their own private beachfront properties. The U.S. Supreme Court is now considering whether Florida’s nourished beaches, constructed with public funds, should be owned by the state or by private landowners.

If the U.S. Supreme Court rules in favor of private landowners, then states might not have authority to prevent development on artificially widened sections of beach, or states might have to pay compensation to landowners to prevent development there.

ESTUARINE SHORELINES THREATENED AS WELL

The S.C. Beachfront Management Act actually has a relatively narrow geographic reach. It was not intended

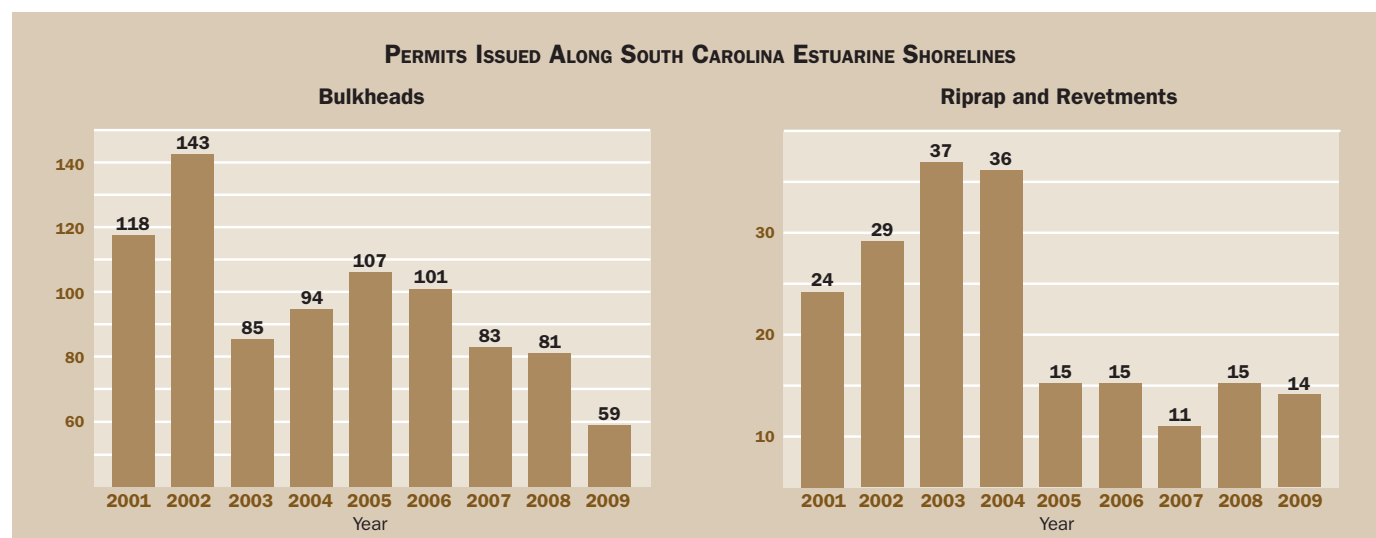
to apply to more than 90% of the state’s shoreline—that is, estuarine shorelines, including bays and harbors, marshy backsides of barrier islands, and mainland marshfronts. Today, many estuarine coasts are lined with high-value properties with primary homes, second homes, retirement homes, and vacation condominiums.

Since 2001, more than a thousand property owners acquired state permits to build bulkheads or other hard, erosion-control structures along these estuarine or “sheltered” shorelines to prevent upland erosion.

Hard structures prevent salt marshes from migrating inland, just as seawalls prevent beaches from doing the same. Wetlands become squeezed between high tides and hard structures, and eventually the marshes are lost.

Over this next century, densely developed parts of our intertidal coast—such as downtown Charleston—might be defended to the last by seawalls and other hard structures. But imagine the cost of engineering the state’s entire estuarine shoreline.

South Carolina has about 2,700 meandering miles of estuarine coastline. That’s longer than the distance from Miami to Seattle. Yet the state lacks policies to manage development and track changes along its sheltered coastlines.



Since 2001, South Carolina coastal regulators have issued 1,067 permits that allow property owners to build hard erosion-control structures along non-beachfront shorelines, including tidal creeks, bay frontage, and behind barrier islands.

SOURCE/S.C. DEPT. OF HEALTH AND ENVIRONMENTAL CONTROL – OFFICE OF OCEAN AND COASTAL RESOURCE MANAGEMENT

"We don't have the kind of monitoring, regulatory, and planning mechanisms for estuarine shorelines that we have for beachfront shorelines," says Braxton Davis of SCDHEC-OCRM.

Now the S.C. Shoreline Change Committee report recommends that the state establish 25-foot-minimum vegetative buffers, allowing for selective cutting, for new developments along the state's estuarine shorelines, and variances in special cases. The buffer width could also be determined by local rates of erosion or relative sea-level rise, but in all cases the committee suggests that all hard erosion-control structures within the 25-foot buffer be prohibited.

With tax credits and other incentives, existing developments would be encouraged to establish such buffers, allowing more room for marsh migration, according to the committee's report. A growing number of localities in South Carolina are already establishing shoreline buffers, and some are wider than 25 feet.

SEA-LEVEL RISE COMES HOME

Marine scientist James T. Morris is surprised when he hears about the pace of shoreline change along a stretch of Jeremy Creek marshfront in McClellanville.

"The salt marsh has moved inland by 50 feet in 25 years?" asks Morris, director of the University of South Carolina Belle W. Baruch Institute for Marine and Coastal Sciences. "That's fast."

Then he pieces the puzzle together.

Marshfronts naturally sink—or subside—as loose sediments are squeezed under their own weight. But lowcountry marshfronts maintain their elevation by trapping additional sediments from the flow of muddy rivers.

When high tides swell across the salt marsh, *Spartina alterniflora* leaves capture water-borne sediments, which settle there as the tide recedes. By trapping mud, *Spartina* builds its root



FLOOD-PRONE. Daniel Fifis, who lives on Jeremy Creek in McClellanville, points out the high mark of recent flooding, covering one-fourth of his three-acre lot, during extreme tides.

PHOTO/WADE SPEES

system higher and its leaves grow higher and thicker. But salt marshes don't have much margin for error. They can eventually sink if local sediment supplies are reduced and sea level rises.

The U.S. Army Corps of Engineers dredges Jeremy Creek and the nearby Intracoastal Waterway to improve navigation, withdrawing sediments and depositing them in spoil sites outside of the local ecosystem. The dredged sediments, then, aren't available to circulate into adjacent salt marshes. Deepening waterways also allows currents to run faster, which erodes shorelines. In fact, dredging waterways and withdrawing sediments from local ecosystems have contributed to wetland losses along the U.S. Atlantic and Gulf coasts.

Natural subsidence, boat wakes, storms, and sea-level rise have probably also affected sections of the Jeremy Creek marshfront, says Morris.

And, over time, ocean warming and land-based ice changes will drive up global sea level, overwhelming every other manmade and natural influence. Many marshfronts will migrate inland, but landowners could block this migration with bulkheads or other

erosion-control structures, and coastal marshes would disappear as a result.

South Carolina officials consider issuing a permit for a bulkhead or other hard erosion-control structure along the immediate edge of a tidal creek only when that waterway is eroding a property's high land in the state's intertidal region.

A landowner, however, would not receive a state permit if salt-marsh vegetation is migrating into an upland area and there is no evidence of erosion. But a landowner with a migrating tidal shoreline could build a bulkhead farther upland on his property where the land is beyond the state's jurisdiction in anticipation of further flooding.

Daniel Fifis says he wouldn't consider installing a bulkhead to protect his property's dry land. "I'm a nature person, a guest of nature. I have problems with building a bulkhead. If I built one, it would affect my neighbors, diverting high tides into their yards. You'd have to bulkhead the entire shoreline to be effective."

SALT MARSHES TO DROWN?

How would the lowcountry's immense salt marshes—like the five-mile-wide stretch of wetlands between McClellanville and the Atlantic Ocean—fare in a warming world? Not too well, says Morris, but signs of trouble won't be visible to the naked eye at first.

Many large, healthy salt marshes are shaped like wide, shallow saucers with modest natural lips or levees along creek edges. High water during tides and storms gets trapped longer in inner regions of marshes than along creek edges. When sea level rises rapidly, *Spartina* plants can't capture adequate sediment to raise themselves above the water. Inner marsh areas become constantly flooded, particularly in the lowest-elevation spots. *Spartina* plants die from stress, sediments disperse, and then the wetland sinks, becoming open water. As a result, a coastline loses invaluable

wildlife habitat and nursery grounds for commercially important fisheries such as shrimp and blue crab.

Sinking holes in the marsh threaten the stability of the entire ecosystem. When *Spartina* die-offs expand outward from the marsh's center, the system becomes a Swiss cheese of remnant wetlands and open water, more easily broken up by the forces of coastal storms. This destructive process has been evident for decades in South Louisiana.

It will also occur in coastal South Carolina. "Many marshes will disintegrate from the inside out," Morris says. "Large areas of South Carolina salt marshes will become open-water lagoons, probably within 50 years. North Inlet is already on its way."

Morris' long-term research in North Inlet, located in Georgetown County, indicates that a significant amount of its immense salt marshes will probably drown by mid-century.

This could be troubling news for marshfront property owners. Studies on the Gulf Coast and elsewhere have shown that large, healthy salt marshes provide crucial storm buffers.

"When you lose miles of salt marshes to open water, you lose storm-surge protection," says Morris. "Larger salt marshes slow wave energy and provide some friction that dampens the height of surges." Numerous recent studies in South Louisiana and elsewhere confirm the storm-buffering capacities of large salt marshes.

Morris is part of a multi-disciplinary NOAA Climate Program Office research effort led by Braxton Davis of SCDHEC-OCRM. Morris will evaluate high-resolution LIDAR (Light Detection And Ranging) elevation maps of salt marshes in four counties—Horry, Georgetown, Charleston, and Beaufort—to identify which wetlands contain a significant number of low-elevation sites and would be most vulnerable to drowning.

Morris is teaming with Paul Gayes of Coastal Carolina University who is studying beachfront changes, and with other scientists who are evaluating



THREATENED ECOSYSTEM. *Karen Sundberg, a research specialist with the Baruch Marine Field Laboratory, measures sediment and plant elevations in the North Inlet estuary. Scientists say that many low-elevation salt marshes will likely drown as sea-level rise accelerates.*

PHOTO/WADE SPEES

social and economic vulnerabilities to climate change in the four counties.

"Losing salt marshes will have major implications for coastal flooding and for property owners, home buyers, and insurance companies," says Morris. "There's a lot of development all over the coast that is right up against the salt marsh. People should know which marshes are most vulnerable to becoming open water. There's a difference between a home buffered by a sea of marsh grass and a home with waves from the open ocean battering a seawall."

South Carolinians need to understand the impacts of global sea-level rise before they make major decisions such as investing in coastal property. But there is one blessing in all this troubling news. Global sea-level rise always lags behind planetary heating. It takes time for water to warm up and expand. It takes time for ice sheets to respond to warming and shed water. Most of this century's global sea-level rise will occur after 2050. South Carolina still has time to plan wisely and adapt to a changing shoreline. ♡

Lessons from the past

In 1900, the most deadly hurricane in American history struck Galveston, Texas, killing an estimated 8,000 people. Storm waves crushed downtown Galveston, which had been constructed on very low terrain just a few feet above sea level.

Afterwards, the city raised the surviving downtown buildings a complete floor, filled under them with dredged sediments, and built a seawall to protect its Gulf waterfront. This combination of engineering techniques saved downtown buildings from devastation during a major hurricane more than a century later.

In September 2008, Hurricane Ike battered the city with a 15-foot storm surge and pounding waves, yet the Galveston's downtown behind the seawall remained intact.

"I'm not saying that Galveston had an elegant solution or one that's in concert with nature or long-term sea-level rise," says Abby Sallenger who

runs the U.S. Geological Survey storm-impacts research group, which studies how extreme storms change coastal areas. "But they realized that on extraordinarily low land, elevating buildings was fundamental to the problem, and they did something about it. What they did following the 1900 hurricane saved them during Ike."

Ike's storm surge did flood downtown from the marsh side of the island, which was largely unprotected. But "it wasn't a violent flood with waves crashing into buildings," says Sallenger, and most structures there survived intact.

The Bolivar Peninsula, located across a shipping channel from downtown Galveston, is also a low-elevation site. The peninsula's peak elevation is only five to six feet above sea level.

Some 3,000 individual structures had been constructed in suburban-style developments there decades after

the 1900 storm. Many homes were raised on pilings but others were not.

"The Bolivar Peninsula had the lesson of what happened a few miles away in Galveston in 1900, yet people there built on low terrain and didn't build a seawall," says Sallenger. "Some houses on the Bolivar Peninsula were elevated, but just not elevated enough. When Ike hit, huge waves on top of the surge got above the pilings and into the structures."

Ike's surge destroyed thousands of homes, scattering their debris across the peninsula. "All you saw after the storm were bare pilings, their houses stripped," says Sallenger. "You could see where the houses had been, but they were just gone."

Many older homes are similarly built low to the ground near salt marshes and tidal creeks throughout the South Carolina lowcountry. A typical older house near a South Carolina salt marsh has an occupied first floor less than 10 feet above mean high tide. Many of these homes are on sea islands and other vulnerable locations.

Starting in the 1970s, coastal communities began joining the National Flood Insurance Program, which requires new and substantially remodeled flood-prone structures to be elevated on pilings or tall foundations. Some Bolivar Peninsula homes were constructed after the flood-insurance program came into effect.

Hurricane Ike showed that lifting individual homes on pilings in very low-elevation locations won't necessarily save them in a major storm surge, particularly if nearby homes aren't elevated. Ike's storm surge knocked down homes and drove them into neighboring structures.

Spencer Rogers, a coastal construction and erosion specialist with the North Carolina Sea Grant Program, says that surviving houses on the Bolivar Peninsula typically had



COLLAPSED. An opened path through rubble following the 1900 hurricane that devastated Galveston, Texas.

PHOTO/LIBRARY OF CONGRESS

floor-joist elevations two to four feet higher than the minimum required elevations in the local flood regulations. “Some homeowners chose to build higher than required,” says Rogers, “and that choice frequently saved their houses.”

One lesson from Ike and other giant storms is that some very low-elevation places should never be developed or redeveloped because they’re just too dangerous in major hurricanes, says Sallenger.

In his 2009 book, *Island in a Storm*, Sallenger vividly describes the human and ecological consequences of a massive storm that blasted Isle Derniere, a 25-mile-long, low-elevation barrier island on the central Louisiana coast, in August 1856.

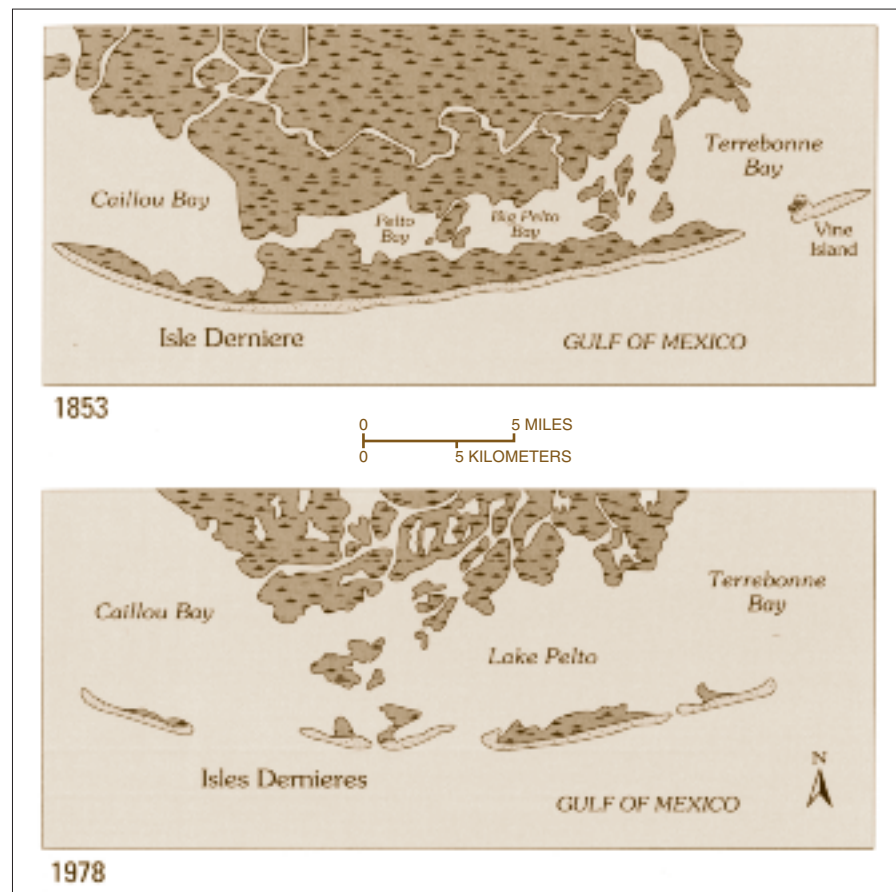
In the 1840s and 50s, a resort was built on Isle Derniere, and developers planned a much larger one. Wealthy planters and merchants from across South Louisiana visited the island to escape hot, disease-ridden cities and towns.

Then, with no warning, a massive hurricane killed half of the 400 people on the island.

“When their community was wiped out, the survivors looked at what had happened,” says Sallenger. “They had planned to build the largest resort in the country on that island. But they didn’t rebuild any houses. What we do today is that as soon as a

barrier island gets hit really hard, we rebuild bigger and fancier and put more people at risk. After the 1856 storm, the survivors of Isle Derniere

saw an island that rose not much higher than a desktop and they said this is no place to put investments or people.” ♡



This map shows the deterioration of Isle Derniere in the Gulf of Mexico south of New Orleans over a span of 125 years. Coastal scientists say that similar deterioration will occur on East Coast barrier islands during this century because of sea-level rise.

MAP/U.S. GEOLOGICAL SURVEY



Reading and Web sites



Archer, David. *The Long Thaw: How Humans are Changing the Next 100,000 Years of Earth's Climate*. Princeton, N.J.: Princeton University Press, 2009.

Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region.

A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research, January 2009. www.climatechange.gov/Library/sap/default.htm

Global Climate Change Impacts in the United States. A report by the U.S. Global Change Research Program, June 2009.

<http://globalchange.gov/publications/reports/scientific-assessments/us-impacts>

Intergovernmental Panel on Climate Change. www.ipcc.ch

National Oceanic and Atmospheric Administration (NOAA) Climate Service. www.noaa.gov/climate.html
NOAA National Climatic Data Center www.ncdc.noaa.gov/oa/ncdc.html

Pilkey, Orrin H. and Rob Young. *The Rising Sea*. Washington, D.C.: Island Press, 2009.

Sallenger, Abby. *Island in a Storm: A Rising Sea, a Vanishing Coast, and a Nineteenth-Century Disaster that Warns of a Warmer World*. New York: PublicAffairs, 2009.

S.C. Department of Health and Environmental Control-Office of Ocean and Coastal Resource Management. *Adapting to Shoreline Change: A Foundation for Improved Management and Planning in South Carolina*. Final Report of the Shoreline Change Advisory Committee. April 10, 2010. www.scdhec.gov/environment/ocrm

NEWS & NOTES

Consortium receives National Sea Grant funding for 2010-2012

The National Sea Grant College Program has awarded \$1.28 million to the S.C. Sea Grant Consortium to support its first-year research, extension, communications, and education efforts for 2010-2012. Eleven research and education projects have received funding to examine marine- and coastal-resource needs. Visit www.scseagrant.org/research for more details.

The Coastal and Ocean Landscape

- Submarine Groundwater Discharge to Long Bay, S.C.: Preliminary Assessment of Land Use Impact, Geological Controls, and Nutrient Loads. **Richard Viso**, Coastal Carolina University.
- Characterization of Wave and Current Energy Levels in Estuarine Waters for Ecological and Particulate Dispersion Studies: Case Study Winyah Bay, S.C. **George Voulgaris**, University of South Carolina.

Sustainable Coastal Development and Economy

- Infiltration versus Retention for Stormwater Quantity and Quality Management: A Continued Assessment of Rainfall Response in Coastal South Carolina Watersheds. **Dan Hitchcock**, Clemson University.
- Linking Residential Development and Organic Matter Loading to the Coastal Zone: The Role of Stormwater Ponds as Sources of Bioreactive Organic Carbon and Nitrogen. **Erik Smith**, University of South Carolina.

Sustainable Fisheries and Aquaculture

- Tagging of Horseshoe Crabs in Conjunction with Commercial Harvesters and the Biomedical Industry in South Carolina. **Larry DeLancey**, S.C. Department of Natural Resources.
- Drought and Decline of Blue Crabs in South Carolina. **Michael Childress**, Clemson University.
- Development of Non-Lethal Genetic Techniques for Age and Sex Determination in Two Recreationally Important Fishes in South Carolina. **Tanya Darden**, S.C. Department of Natural Resources.
- Evaluating the Comparative Survival and Growth of Diploid and Triploid Single Eastern Oysters in South Carolina. **Peter Kingsley-Smith**, S.C. Department of Natural Resources.
- Commercialization of Bait Shrimp (*Litopenaeus setiferus*) Aquaculture through Year-Round Production in Indoor Facilities Using Clear Water and Biotic-based Culture Systems. **John Leffler**, S.C. Department of Natural Resources.

Hazard Resilience in Coastal Communities

- Predicting Building Envelope Failures of Residential Structures Due to Atlantic Basin Hurricane Wind Hazard. **Wei Chiang Pang**, Clemson University.

Scientific Literacy and Workforce Development

- The Gulf Stream Transect Oceanography Program (GuSTO): Undergraduate Workforce Training

in Ocean Science Research. **Leslie Sautter**, College of Charleston. ♡

Coastal network addresses shoreline change

The South Carolina Coastal Information Network recently hosted a workshop series titled "South Carolina's Changing Shoreline: Implications for the Future." The workshops were held in each of the state's coastal regions: the Lowcountry (Beaufort, Colleton, and Jasper counties), Berkeley-Charleston-Dorchester, and the Waccamaw (Georgetown and Horry counties).

These events complemented the S.C. Department of Health and



Participants at the workshop in Charleston listened to a presentation about sea-level rise. PHOTO/S.C. SEA GRANT EXTENSION PROGRAM

Environmental Control—Office of Ocean and Coastal Resource Management Community Leaders' Discussion Forums held in 2009. The workshops featured scientists and resource managers who presented information on the status of climate, sea level, and shoreline change in South Carolina.

Attendees included local elected and appointed government officials,

NEWS & NOTES

municipal staff, resource managers, public health managers, and other community leaders. For more information about this workshop series, contact April Turner at April.Turner@scseagrant.org, call (843) 953-2078, or visit www.scseagrant.org/content/?cid=42. ♡

Consortium spins off SECOORA as nonprofit corporation

On March 17, 2010, the Southeast Coastal Ocean Observing Regional Association (SECOORA; www.secoora.org) was spun off from the S.C. Sea Grant Consortium and officially became an independent, nonprofit corporation.

SECOORA, one of 11 ocean observing regional associations established nationwide through the Integrated Ocean Observing System (IOOS®) network, coordinates coastal and ocean observing activities and facilitates dialogue among stakeholders in the southeastern United States.

In 2002, the S.C. Sea Grant Consortium was approached by a number of university and ocean observing leaders in the southeastern United States to lead the development of and initially manage the region's ocean observations program. A diverse 10-member Steering Committee, consisting of representatives from state government, academia, industry, and business, was formed to oversee and direct the growth of the organization.

In October 2003, the SECOORA effort officially began through a grant award from the NOAA Coastal Services Center to the S.C. Sea Grant Consortium. Over

the last eight years, the Consortium and SECOORA have successfully competed for more than \$6 million in federal NOAA funding to support the organization's growth and maturation, focusing on its ocean observing assets, data generation and integration, stakeholder engagement, and organizational and fiscal management.

SECOORA was incorporated in the state of South Carolina as a nonprofit organization in September 2008, and has an annual operating budget of about \$400,000. SECOORA consists of 41 dues-paying member organizations, and a host of partnering institutions. SECOORA's executive director, Debra Hernandez, oversees five staff. ♡

Coastal ecologist wins S.C. Environmental Awareness Award

Fred Holland of Charleston has been named winner of the 2009 S.C. Environmental Awareness Award at an award ceremony held in Columbia March 31, 2010.

Holland was recognized by Scott English, Governor Mark Sanford's Chief of Staff, for his outstanding contributions to estuarine and coastal ecology research, as well as his lifelong dedication to the state's coastal environment.

"Fred Holland is not just a steward of natural resources in South Carolina, he is a pioneer and, in some cases, a national trendsetter for protecting and preserving our coastal resources," English said in making the presentation.

Holland, a native South Carolinian, became director of the

S.C. Department of Natural Resources' Marine Resources Research Institute at Fort Johnson in Charleston in 1991. In 2001, Holland was named director of the National Oceanic and Atmospheric Administration's Hollings Marine Laboratory until his retirement in 2008.



Fred Holland (left) accepted the 2009 S.C. Environmental Awareness Award from Governor Mark Sanford's Chief of Staff Scott English. PHOTO/S.C. DEPT. OF HEALTH AND ENVIRONMENTAL CONTROL

"Fred's legacy is important for two reasons," English said. "He has been able to translate in-depth scientific research for policymakers and the average person in making decisions that affect our communities. At the same time, he has mentored a new generation of marine scientists who will carry on his work in marine sciences."

The S.C. General Assembly established the S.C. Environmental Awareness Award in 1992 to recognize outstanding contributions toward the protection, conservation, and improvement of South Carolina's natural resources.

The award is sponsored by the S.C. Sea Grant Consortium, S.C. Department of Natural Resources, S.C. Department of Health and Environmental Control, and the S.C. Forestry Commission. ♡



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EBBS & FLOWS

140th Annual American Fisheries Society Conference

*Pittsburgh, Pennsylvania
September 12-16, 2010*

This annual conference brings together fisheries professionals from around the nation to share their expertise, research, and outreach programs to build a stronger professional fisheries network. This year, the meeting theme will be "Merging our Deeper Currents." For more information, visit the conference Web site at www.fisheries.org/afs10.

Working Waterways and Waterfronts National Symposium on Water Access

*Portland, Maine
September 27-30, 2010*

This symposium will provide a forum to help communities, organizations, and individuals address waterfront access challenges by showcasing successful models and tools from around the country. Speakers will discuss the economic, social, and environmental values of waterfront uses as part of sustainable communities. Visit www.wateraccessus.com for more information.

13th International Conference on Shellfish Restoration

*Charleston, South Carolina
November 17-20, 2010*

The theme of this year's gathering will focus on the progress made in shellfish restoration over the past 25 years and how these efforts have shaped the role of future restoration projects. Presentations will cover many topics, including habitat restoration, stock enhancement, and watershed management. For more information, visit www.scseagrant.org/content/?cid=297.

Subscriptions are free upon request by contacting: Annette.Dunmeyer@scseagrant.org

ATTENTION SCHOOL TEACHERS! The S.C. Sea Grant Consortium has designed supplemental classroom resources for this and past issues of *Coastal Heritage* magazine. *Coastal Heritage Curriculum Connection*, written for K-12 educators and their students, is aligned with the South Carolina state standards for the appropriate grade levels. Includes standards-based inquiry questions to lead students through explorations of the topic discussed. *Curriculum Connection* is available on-line at www.scseagrant.org/education.